Movements, Habitat Use, and Survival of Mountain Quail (*Oreortyx pictus*) during Fall and Winter in west–central Idaho.

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Idaho Department of Fish and Game
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by

Kerry P. Reese
Professor of Wildlife,

Pamela J. Nelle
Research Associate
Department of Fish and Wildlife Resources
University of Idaho

and

Pete Zager
Idaho Department of Fish and Game
1540 Warner Avenue
Lewiston, ID 83501

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Kerry P. Reese and Pamela J. Nelle, Department of Fish and Wildlife Resources, University of Idaho, Moscow, ID 83844–1136, and Pete Zager, Idaho Department of Fish and Game, 1540 Warner Ave., Lewiston, ID 83501

Introduction

Mountain quail (Oreortyx pictus) numbers in Idaho have been declining over the past several decades. Mountain quail have been classified as a "Species of Special Concern" by the Idaho Department of Fish and Game (IDFG), and as a "Sensitive Species" by the Bureau of Land Management and Region 4 of the U.S. Forest Service (USFS) (Moseley and Groves 1990). Current distribution of mountain quail in Idaho is greatly reduced from its historical distribution (Brennan 1990), and little is known about its ecology. Our objectives were to:

1. Describe characteristics of habitat used by mountain quail in the fall and winter.
2. Determine daily and seasonal movements and home range size of radio–marked mountain quail during the fall and winter.
3. Determine survival rates of mountain quail over the fall and winter.

Study Area

The study area included drainages of the Little Salmon River in the southwest corner of Idaho County, Idaho (Fig. 1). Most of the land is publicly owned, and livestock grazing, mining and logging are the predominant land uses. The area consists primarily of steep, dissected slopes with basaltic outcrops and ridges. South-facing slopes are generally arid and dominated by perennial grasses such as bluebunch wheatgrass (Agropyron spicatum) and Idaho fescue (Festuca idahoensis), and several forb species. On mesic north-facing slopes and in small draws shrubs such as serviceberry (Amelanchier alnifolia), ocean spray (Holodiscus discolor), black hawthorn (Crataegus douglasii), ninebark (Physocarpus malvaceus), snowberry (Symphoricarpus albus), and rose (Rosa spp.) are common. Elderberry (Sambucus spp.), alder (Alnus spp.), and cottonwood (Populus spp.) are found along stream bottoms and near springs and seeps, and Ponderosa pine (Pinus ponderosa) and Douglas-fir (Pseudotsuga menziesii) are present on higher elevation north–facing slopes and draws.

The average annual temperature is 12°C, and winter temperatures are sometimes colder in the valleys than in the lower elevations of adjacent mountains due to cold air movements (U.S.D.A. 1982). Average annual precipitation is 35.6 cm, with peaks in the spring and fall. Elevation in the Salmon and Little Salmon River corridors ranges from 244–852 m (Ormiston 1966, Barker et al. 1983).

Methods and Analysis

Mountain quail were trapped during the fall and winter of 1993 and 1994 using modified Stoddard quail traps (Stoddard 1936, Schultz 1950, Gooden 1953, Ormiston 1966, Smith et al. 1981). Traps were baited with millet and waste grain and were concealed under the cover of shrubs (Gutiérrez 1977, 1980). Trapping began in mid-January and ended when the birds moved to nesting habitat in late February/ mid–March.

Each captured mountain quail was fitted with a poncho–mounted, battery–powered radio transmitter (Pyrah 1970, Amstrup 1980). The combined weight of the radio and poncho was approximately 7.1 ± 1 g, which was < 4% of the mean body weights of male (235 g, n = 30, Johnsgard 1973) and female (230 g, n = 24, Johnsgard 1973) mountain quail. We attempted to determine the sex of captured quail by the color of the plumage on the hind neck (McLean 1930). However, in the fall, because of the molt, this method is unreliable, especially in juveniles (Heekin et al. 1996). Therefore, age of quail, adult or juvenile, was determined using the methods of Leopold (1939).

Radio–collared mountain quail were monitored from October 1994 through March 1995, and from September 1995 through February 1996. Birds were located once or twice a week using a portable scanning receiver and a hand–held, 3–element Yagi antenna, and were circled at a close range to determine their location without flushing them (Springer 1979). Data recorded at mountain quail locations included UTM coordinates, elevation (m), cover type, number of birds present, bird activity, and snow conditions. Due to different weather conditions over the 2 field seasons, data from radio–collared bird locations were not pooled between years. Sites where birds were found dead were not included in data analysis, and locations with > 1 radio–collared bird in a covey were treated as 1 observation. Differences were considered significant at $\alpha = 0.05$ for all tests.

Covey size

Covey size was calculated as the minimum number of birds seen at each radio–collared bird location. A Mann–Whitney U test was used to determine if covey size differed between years, and covey size was regressed against Julian date to determine if covey size changed over time.

Cover type

Cover types at mountain quail locations were described using 10 categories: (1) riparian/tree/shrub; (2) riparian/shrub; (3) mountain/shrub; (4) conifer/shrub; (5) grassland/scattered shrub; (6) agriculture; (7) residential garden; (8) road; (9) grass, and (10) rocky outcrops. The number of different cover types used and the % of observations recorded in each cover type in each year were calculated for diurnal and nocturnal locations. The % of observations in each cover type by month was also calculated.

Elevation

Elevation at mountain quail locations was estimated from 7.5 minute topographic maps. A Mann–Whitney U–test was used to test for differences in diurnal elevation between years at mountain quail locations. There was insufficient data on nocturnal locations to test for differences between nocturnal elevation between years.

Snow depth

Snow depth at telemetry locations was measured at the center of each mountain quail location and at 4 points from the center in the cardinal directions. A Mann–Whitney U–test was used to test if there was a difference in mean snow depth at mountain quail locations between years. Precipitation and minimum temperature data were available from a weather station in Riggins, Idaho.

Activity patterns

When radio–equipped mountain quail were observed, their activity was recorded as 1 of the following: (1) loafing, (2) foraging, (3) loafing/foraging, (4) roosting, (5) moving, (6) moving/foraging, and (7) using security cover. These were then summarized into 3 categories: (1) active (foraging, moving, moving/foraging) (2) inactive (loafing, roosting), and (3) unspecified (loafing/foraging, security cover). The percent of observations of each activity was calculated, as well as the cover type associated with each activity. The activities of mountain quail and the relationship to the time of day in which they were observed was analyzed by dividing the day into 5 time periods: 2400-0530, 0530-1000, 1000-1500, 1500-1700, and 1700-2400, and calculating the % of observations in each time period.

Fall and winter home range

Mountain quail home ranges were calculated using program Calhome (Kie et al. 1996). Home ranges were estimated using the Minimum Convex Polygon (MCP) method and the Adaptive Kernel (AK) method. Individual mountain quail with a minimum of 10 locations in 1994/95 and a minimum of 9 observations in 1995/96 were used to estimate home range. A Mann–Whitney U–test was used to test for differences in home range size and distances moved between years.

Covey sites

Habitat characteristics were measured at mountain quail diurnal roost sites and independent locations over both fall and winter periods. Habitat characteristics at covey locations were measured by returning to the location after the covey had moved. Independent random sites were selected by generating random UTM coordinates within the drainage boundary. At each covey and independent site 4, 8–m tapes were placed in the cardinal directions from the center of the location and the following microsite variables were measured: (1) percent cover by shrub and tree species, estimated using the line intercept method (Canfield 1941); (2) species and height of the tallest shrub at the center and nearest the 4–m tape points, measured with a meter stick or estimated if > 3 m; (3) species and height of trees at the center and 4 ends of the tapes, estimated to the nearest 1 m; (4) overstory canopy, estimated by averaging densiometer readings taken at the center and 8–m points (Lemmon 1956, Strickler 1959); (5) density of cover up to 1.5 m using a Robel pole (Robel et al. 1970) at the center and 4–m points of the tapes; (6) slope and aspect, measured using a compass and clinometer; (7) elevation, estimated from topographic maps; (8) estimated distance in meters to nearest water source (9) snow depth at the center and at 1–m and 8–m points of the tapes.

Data were analyzed using a MANOVA to test for differences in habitat characteristics between sites and years. The following variables were included and, where appropriate, were transformed to normalize the data: (1) % slope; (2) elevation (m); (3) % tree canopy closure; (4) height of tallest shrubs (cm); (5) vertical cover; (6) snow depth (cm); (7) % total canopy cover; (8) height of trees (m); (9) tree dbh (cm), and (10) distance to nearest water source (m).

Percent canopy cover at independent and covey locations was analyzed by pooling the data between years and dividing it into 3 categories: shrubs, trees and others. "Others" includes dead and standing (D&S), dead and downed (D&D) woody debris, and coarse woody debris (CWD). T-tests were used to determine if the % canopy cover of each category differed between covey and independent sites. Common and scientific names of plants sampled are presented in Appendix A. The aspect of covey and independent sites was analyzed using the Watson–Williams test for circular distributions (Zar 1984).

Survival estimates

Survival estimates for fall and winter in both years were calculated using a staggered entry Kaplan–Meier method (Kaplan and Meier 1958, Pollock et al. 1989b, c). Interval (Oct 1994–Mar 1995 and Sept 1995–Feb 1996) and monthly survival rates were calculated. The Kaplan–Meier method requires several assumptions: birds are randomly sampled, left–censored individuals have survival distributions similar to previously marked birds, survival times for individuals were independent, censoring mechanisms were independent of animal fate, and that trapping, handling, and radio–marking did not affect survival probability (Pollock et al. 1989a, b, White and Garrot 1990).

Results

Seventy–three radio–collared birds were monitored from October 1994 through March 1995, and 40 radio–collared birds were monitored from September 1995 through

February 1996. A total of 235 locations were recorded in 1994/95, of which 206 were diurnal locations and 29 were nocturnal locations. In 1995/96, 113 locations were recorded, 107 of which were diurnal and 6 of which were nocturnal (Table 1).

Covey size

Covey size was not different between years ($Z = -0.455$, $P = 0.649$) as determined by minimum number of birds observed at radio–telemetry locations. Mean covey size and SE was 6.2 ± 0.3 in 1994/95, and 6.5 ± 0.5 in 1995/96. Covey size ranged from 1 to 21 birds in the fall and winter of 1994/95, and from 1 to 30 birds in 1955/96 (Figs 2 and 3, respectively). In both years, the greatest proportion of coveys ranged from 1 to 4 birds in size (48% of coveys in 1994/95 and 44% of coveys in 1995/96, Fig. 4). Thirty–two percent and 33% of coveys ranged from 5 to 8 birds in 1994/95 and 1995/96, respectively. Coveys of 9 to 12 birds formed 17% of coveys in 1994/95, and 13% in 1995/96, and coveys of 13 or more birds only accounted for 4% of coveys in 1994/95, compared to 10% in 1995/96 (Fig. 4).

Covey size did not change over time ($r^2 = 0.06$, $P = 0.144$), although the proportion of covey size categories in each month changed as the winter progressed. Small coveys of 1–4 and 5–8 birds were most abundant in all months, but 1–4 bird coveys became most common (> 50%) during February and March 1995 (Fig. 5) and during January and February of 1996 (Fig. 6), perhaps as a result of birds beginning to pair for nesting. In both years, larger coveys (9+ birds) were not common in any month, and were always ≤ 25% of observed coveys, except in November and December of 1994 and November 1995, when they comprised 37, 33 and 28% of observed coveys, respectively (Figs. 5 and 6). The age ratio of birds captured in fall was 4.5 juveniles per adult in 1994, and 4.9 juveniles per adult in 1995.

Cover types

Mountain quail generally used a wider variety of diurnal cover types during the fall and winter of 1994/95 than in 1995/96, except in January when birds were located in 7 different cover types in both years (Fig. 7). In the fall and winter of 1994/95 the most frequently used diurnal cover type was conifer/shrub (37% of observations), and only 15% of observations were in grass/scattered shrub habitat (Fig. 8). In the fall and winter of 1995/96 grass/scattered shrub was used most frequently (40%) and 33% of observations were in conifer/shrub habitat (Fig. 8). Mountain quail were not found in mountain/shrub or agricultural cover types in 1995/96, and rocky outcrop was the only cover type not used in either year. Riparian/tree/shrub and residential garden cover types were used more in 1994/95 than in 1995/96.

In each month from October 1994 to February 1995, most diurnal mountain quail locations were in conifer/shrub habitat, until March 1995, when mountain quail were found most often in the grass/scattered shrub cover type during the day (Table 2). In 1995/96, diurnal mountain quail locations were in grass/scattered shrub most frequently in all months from October 1995 to February 1996, except in November 1995, when most locations were in conifer/shrub.

In 1994/95 most nocturnal locations (34%) were recorded in the conifer/shrub cover type, compared with 1995/96, when most nocturnal locations (50%) were in the grass/scattered shrub cover type (Fig. 9). Mountain quail were not recorded roosting in riparian/shrub, agricultural, road, or rocky outcrop cover types in either winter, and were found roosting in riparian/tree/shrub, mountain/shrub, and grass cover types only during the winter of 1994/95. Nocturnal cover types were not analyzed by month due to the small sample sizes.

Elevation

In the fall and winter of 1994/95 the mean elevation and SE (885 m ± 11 m) for all diurnal mountain quail locations was significantly lower than the fall and winter of 1995/96 (965 m ± 17 m; Z = -4.006, P = 0.000; Fig. 10). There were insufficient nocturnal locations to allow a statistical comparison between nocturnal and diurnal elevation and nocturnal elevations used between years. However, mean elevation at nocturnal locations was 869 ± 24 m in 1994/95 and 890 ± 76 m in 1995/96.

Snow depth

Total monthly precipitation was less in the fall and winter of 1994/95 compared to 1995/96 (t = -1.79, P = 0.05). Mean monthly minimum temperatures were similar in both years (t = 0.07, P = 0.47, Fig. 11).

Mean snow depth at mountain quail locations was not different between the 2 winters (1.4 cm ± SE 0.2 cm in 1994/95, 1.3 cm ± SE 0.3 cm in 1995/96; Z = -0.05, P = 0.627), but the timing of heaviest snowfall differed between years (Fig. 12). In the winter of 1994/95 the greatest mean snow depth at mountain quail locations was in December (3.9 cm), compared to the winter of 1995/96 when the greatest average snow depth at mountain quail locations was in January (2.7 cm deep). Snow depth ranged from 0–14 cm in the fall and winter of 1994/95, and from 0–15 cm in 1995/96 at mountain quail sites.

During the winters of 1994/95 and 1995/96, mountain quail used the conifer/shrub cover type most frequently (36%) when snow depths were < 1 cm (Table 3). In 1994/95 mountain quail exhibited no obvious preference for cover type in snow depths of 1.1–5.0 cm, as they were observed equally often in riparian/tree/shrub, conifer/shrub, and grass/scattered shrub cover types. However, in the winter 1995/96, mountain quail use was concentrated on grass/scattered shrub habitat in snow depths of 1.1–5.0 cm. In snow depths of 5.1–9.9 cm, mountain quail were observed in conifer/shrub in 54% of observations in 1994/95, compared to 1995/96 when most observations (67%) were in grass/scattered shrub. When snow depth at mountain quail locations was > 10 cm in 1994/95, mountain quail were predominately found in conifer/shrub (67%), but in 1995/96 80% of observations were in grass/scattered shrub habitats. However, the sample size was small for this snow depth (n = 6 in 1994/95 and n = 5 in 1995/96). Most importantly, under all snow conditions during both years, 54% to 100% of mountain quail locations were in either conifer/shrub or grass/scattered shrub cover types.

Activity

In the fall and winter of 1994/95, mountain quail were active in 50% of the observations, compared to 45% of observations in 1995/96 (Fig. 13). Birds were inactive in 38% of observations in 1994/95 compared to 49% of observations in 1995/96.

Activity in different time periods

In 1994/95, most activity was observed between 0530 and 1500, compared to 1995/96 when most activity was observed between the hours of 1000 and 1700 (Table 4). In both years mountain quail were observed to be inactive most frequently between the hours of 1000–1500.

Fall and winter home range

Twenty–four radio–collared mountain quail were relocated ≥ 10 times in 1994/95 and 12 radio-collared mountain quail were relocated ≥ 9 times during 1995/96. Mountain quail home range estimates using the MCP and Adaptive Kernel methods, with 80% and 70% of data, were smaller in 1994/95 than in 1995/96 (Table 5). Estimated home range sizes averaged, depending on method of calculation, from 11 to 52 ha in 1994/95, and from 15 to 83 ha in 1995/96. Mountain quail also moved shorter distances between consecutive locations in 1994/95 than in 1995/96 (405 m versus 619 m), but neither distances moved, nor home range sizes, were different between years (80% of data, $Z = -1.376$, $P = 0.177$; 70% of data, $Z = -1.175$, $P = 0.251$).

The mean length of time over which birds were monitored was longer in 1994/95 than in 1995/96. In 1994/95 radio-collared mountain quail were monitored for an average of 115 days. The shortest time any bird used in analysis was followed was 41 days, and the maximum number of days any bird was followed was 63. In 1995/96 radio–collared birds were followed for an average of 91 days (range = 60 - 133 days) (Table 6).

Covey sites

During the fall and winter of 1994/95, 22 covey sites and 21 independent sites were surveyed, and 17 covey and 17 independent sites were surveyed during the fall and winter of 1995/96. Covey sites were surveyed in each month in both years except for March 1996 (Table 7).

Habitat characteristics did not differ between covey sites between years, nor between independent sites between years. Habitat data were therefore pooled between years and tested for differences between covey sites and independent sites, which were different ($F = 8.5437$, $P = 0.0001$).

Mountain quail covey sites were at lower elevations than independent sites, had taller shrubs, more visual obstruction, less snow depth, greater vegetative canopy cover, smaller trees, and were closer to water compared to independent sites (Table 8). Percent slope, percent canopy closure, and tree dbh did not differ between covey and independent sites.

Because the majority of covey sites sampled were recorded as diurnal roosting sites (only 5 of 38 covey sites over both winters were nocturnal roost sites), nocturnal and diurnal covey sites were pooled. In the fall and winter of 1994/95 mountain quail covey sites had a mean aspect of 65° and a mean aspect of 80° in the fall and winter of 1995/96 and years were pooled. The mean aspect of covey sites, 74,^{0} differed ($F = 9.7$, $P \leq 0.05$) from the mean aspect of independent sites, 5^0. Thus, mountain quail covey sites were found on approximately east–facing slopes, compared to independent sites, which were located on more north-facing slopes. Covey site aspect did not differ between years ($F = 0.3$, $P > 0.05$).

The pooled data on covey locations were further analyzed using a MANOVA to determine if there were any changes in habitat characteristics by month. For all variables tested, covey sites did not differ by month ($F = 1.0651$, $P = 0.3893$, Table 9). Independent sites did not differ in % canopy closure, shrub height, vertical cover, snow depth, and % shrub canopy cover by month ($F = 0.5026$, $P = 0.9735$). Further analysis, using regression on each variable measured at covey sites against the Julian date, revealed that only distance to nearest water had a significant relationship ($R^2 = 0.343$, $P = 0.033$) with date surveyed (Fig. 14) and quail were found closer to water as the winter progressed.

Canopy cover from shrubs and trees did not differ between covey and independent sites ($t = 1.30$, $P = 0.10$, and $t = 1.4$, $P = 0.09$, respectively). However, canopy cover from woody debris was greater at covey sites than at independent sites ($t = 3.3$, $P = 0.005$, Fig. 15).

Twenty shrub species occurred at covey sites and independent sites (Table 10), but only 14 species occurred at both covey and independent sites. In 1994/95, the major shrub species were black hawthorn (47%), ninebark (35%), serviceberry (31%), current (31%), and dogwood (22%). Curleaf mountain mahogany (44%) was the dominant shrub at covey sites in 1995/96, followed by black hawthorn (35%), syringa (17%), and ninebark and serviceberry with 14% each (Table 10). Dominant shrubs at independent sites were ocean–spray, dogwood, hawthorn, syringa, and ninebark. Willow was absent at covey sites in 1994/95 and was only 1% of shrub cover in 1995/96, but in these years willow was 10% and 11% of the cover at independent sites, respectively.

At covey sites in both years, water birch (Betula occidentalis) and juniper had the greatest canopy coverage of the trees present (Table 10). In 1994/95 exotic species (51%), junipers (37%) and black cottonwood (32%) were other major canopy species, while in 1995/96, Rocky Mountain maple (16%) was another canopy species. In both years, birds used areas with higher percent cover of dead and down, and dead and standing material (Table 10).

Survival estimates

Telemetry locations used for survival estimates were not part of a regular or standardized sampling schedule, but were the result of incidental locations during vegetation sampling and flush counts. As a result, there were a large number of censored birds and a number of radio–marked birds which were never located and thus were not included in the analysis. A number of birds were also located only once or so infrequently that they could not be used as part of the survival estimate. Corrections based on uncertainty of relocations (Bunck et al. 1995) for some individual birds were used where there were large gaps in frequency of location, but in this case there were no detectable differences in survival estimates. As a result, survival estimates presented should be considered approximations only. No estimates were made with respect to sexes because accurate information on the sex of radio–marked birds was not available at the time of analysis. Concerns about sample size also precluded the estimates of survival for juvenile and adult quail.

Over the fall and winter of 1994/95 mountain quail had higher survival (53% ± SE 36%) than in the fall and winter of 1995/96 (25% ± SE 22%). Figure 16 shows survival estimates, mean snow depth, and mean minimum temperature by month for each fall and winter period. Lowest survival rates in 1994/95 and 1995/96 were associated with the period of greatest snow depth. During the fall and winter of 1994/95, the mortality rate was 26% in December, the period of greatest snowfall that fall and winter, and in the fall and winter of 1995/96, the mortality rate was 58% in January, also the period of greatest snowfall. In the fall and winter of 1944/95, out of 16 recovered carcasses or radio–collars, 38% of deaths were due to avian predators, compared to 41% of 22 in 1995/96 (Table 11). Mammalian predators were responsible for 43% of deaths in 1994/95, compared to only 14% of deaths in 1995/96, although more deaths could not be attributed to a known predator in 1995/96 (45%) compared to 19% in 1994/95. One mortality was attributed to a coyote and one to a bobcat in 1994/95, and 2 kills were attributed to domestic cats in 1995/96.

Discussion

In western Idaho, mountain quail are generally restricted to riparian corridors along waterways and secondary drainages within a few hundred meters of water (Brennan 1989). IDFG (1978) reported a total of 12,739 ha of this riparian habitat available for mountain quail in Idaho. To escape harsh winter weather and snow, mountain quail require shrub habitat at lower elevations. At present, prime low elevation winter habitat is restricted to the Salmon River drainage near the confluence of the Salmon and Little Salmon rivers in northwestern Idaho (Brennan 1990), where this study was conducted. This drainage is free of impoundments, agricultural activity is limited, and the area experiences the mildest winters in the state (Brennan 1990).

Fall covey sizes of mountain quail are generally small, ranging from 6 to 12 birds (Leopold et al. 1981), although birds may aggregate in groups of up to 30 during the fall and winter (Ehrlich et al.1988). Miller and Stebbins (1964) recorded an average covey size of 11 birds in Joshua Tree National Park, California, and during fall migration in northern California coveys averaged 8.1 birds (Enderlin 1947). During the fall and winter in west–central Idaho, the mean covey size of mountain quail was on the low end of reported ranges (6.2 in 1994/95 and 6.5 in 1995/96).

Heekin et al. (1996) reported the average clutch size of mountain quail nests in the study area to be 11.2, range 8–16 (n = 20) in 1994, and 12.1, range 9–15 (n = 15) in 1995, and that nest success was high: 74% in 1994 and 87% in 1995. The age ratios of fall–captured birds, 4.5 and 4.9 juveniles per adult in 1994 and 1995, respectively, along with reproductive success values, suggest that 9 to 10 young should have accompanied many adult pairs in the fall, producing covey of 11 and 12 birds. Our average covey sizes were 6.2 and 6.5 birds. The small average covey size observed suggest several possible explanations: 1) high mortality of chicks between hatching and fall, 2) the age ratio observed in fall–captured birds is biased towards juvenile birds, or 3) covey size was biased low from difficulty in accurately counting covey size as birds move through thick vegetation. Additional research is needed to address this question.

Mountain quail are the only quail in North America in which some populations undertake an altitudinal migration from higher elevation breeding areas to lower elevation wintering areas to escape winter snows (Grinnell and Storer 1924, Sumner and Dixon 1953, Leopold et al. 1981, Erhlich et al. 1988, Brennan 1990). In west–central Idaho movement to lower elevations was observed in conjunction with snowfall. In

1995/96 mountain quail were observed at higher elevations through December compared to 1994/95, as snowfall was light up until January 1995. After heavy snowfall in January 1995, birds moved down to lower elevations. Although mountain quail were found to winter at significantly lower elevations in 1994/95 than in 1995/96, this is probably driven by the different elevations used in December between years, because by January birds wintered at similar elevations in both years. This could not be tested, however, due to small sample sizes by month.

In Idaho, mountain quail are typically found in riparian shrub communities, which may or may not have an open coniferous forest overstory (Ormiston 1966, Brennan 1989). In west-central Idaho, birds were typically found on the edges of cover types. This made classifying sites where birds were located to a single habitat type difficult. Fall and winter habitat use by mountain quail in west–central Idaho was observed mostly in conifer/shrub and grass/scattered shrub habitats. Birds were observed less than expected in riparian areas. Use of riparian shrub habitat may have been observed less than expected in west–central Idaho due to the presence of willow. Mountain quail use sites had little or no willow cover in either year, yet independent sites had 10% and 11% willow cover in 1994/95 and 1995/96 respectively. Brennan (1990) hypothesized that mountain quail avoid willow, because even though willows provide cover, they provide nothing in the way of food. Grazing and trampling effects of cattle eliminate important mountain quail food species, such as elderberry, ribes, and snowberry. However, willow shrubs are resistant to trampling and are often the last shrubs to be eliminated by over–grazing (Brennan 1990). If riparian shrub communities in west–central Idaho are being simplified to predominately willow stands by over–grazing and trampling by cattle, then mountain quail may be forced out of the riparian corridors to find food. In a study in California, heavy grazing removed or stunted 90% of the herbaceous annual plants that mountain quail use for food and non–food annuals increased (Miller 1950).

Mountain quail have been observed to be consistently associated with a microhabitat configuration that consists of tall and dense shrubs in close proximity to drinking water (Brennan et al. 1987). Mountain quail in west-central Idaho were found at sites closer to water, with taller shrubs, more visual obstruction, and greater vegetative canopy cover than independent sites. Average distance to water from covey locations was 142 m in west–central Idaho, similar to the 131 m found by Brennan et al. (1987) in northern California. Brennan et al. (1987) also reported an average maximum shrub height of 3 m, very similar to that found in west-central Idaho, where quail where found at sites with an average maximum shrub height of 2.9 m. However, Brennan et al. (1987) reported perennial shrub canopy cover to be 46% at mountain quail use sites, compared to a mean shrub canopy cover of 15% at use sites in our study area. This suggests that shrub canopy cover may be limiting for mountain quail in west–central Idaho. In western Idaho, available riparian shrub habitat has drastically declined through overgrazing, water impoundments, residential developments, agricultural practices, and other human activities (Murray 1938, Brennan 1990).

Guttiérrez (1977) found that mountain quail in California use areas of high tree crown coverage, abundant shrubs, and steep slopes, and that birds are found inside the forest canopy. In west–central Idaho, no difference was found between tree canopy cover at use versus independent sites and birds were often observed on the edge of cover rather than within forest stands. No difference was found in the percent slope at mountain quail use sites in west–central Idaho compared to independent sites. This is likely a reflection of the generally steep and rugged topography characteristic of the study area. Our results confirm the preference for steeper slopes that is suggested in the literature (Edminster 1954, Guttiérrez 1977).

Mountain quail rarely use open habitats such as annual grasslands and talus slopes and will avoid crossing such cover types (Guttiérrez 1977, 1980, Brennan et al. 1987). In west–central Idaho, mountain quail were never observed using rocky outcrops and were rarely observed in grass and agricultural cover types. Loss of shrub cover due to over–grazing, frequent fires, invasion of exotic annuals and perennials, or conversion to agriculture, could result in the isolation of fragmented populations as mountain quail movements are constrained by large expanses of open ground.

In both years mountain quail were most inactive between 10:00 a.m. and 3:00 p.m. Most activity occurred from sunrise until 10:00 a.m., suggesting that foraging was most intense in the morning during fall and winter. However, some activity was observed at all hours of the day.

Fall and winter home range estimates have not previously been reported for mountain quail. The 11–83 ha estimates in our study represent 5 months of the year in which mountain quail move from late brood–rearing to low elevation winter range. This area may represent a large proportion of the annual home range of the birds. Managers of mountain quail habitat in Idaho must be aware of the extent of the annual range of this species.

In fall and winter months, mountain quail habitat usually consists of mixed species of trees, shrubs, and forbs that provide a varied food source. Acorns, pine seeds, and fruits and berries from various species of shrubs are common foods at this time of the year (Belding 1892, Miller and Stebbins 1964, Ormiston 1966, Gutiérrez 1977). Ormiston (1966) reported that mountain quail habitat in Idaho was dominated by shrubs, which included snowberry, rose, ninebark, serviceberry, syringa, black hawthorn, chokecherry and ocean–spray, and that elderberry and black hawthorn were predominant in the diet of quail collected in the fall. Similarly, in west–central Idaho, mountain quail covey sites were dominated by black hawthorn, ninebark, serviceberry, currant, and dogwood in the fall and winter months of 1994/95. In 1995/96, covey sites were dominated by curleaf mountain mahogany, black hawthorn, syringa, ninebark and serviceberry. Ponderosa pine was 18% of the canopy cover at mountain quail covey use sites in 1994/95, although it was not recorded at use sites in 1995/96. Loss of these shrubs and trees, through anthropogenic causes or fire, would negatively impact fall and winter habitat quality.

Harsh winters can have a negative impact on mountain quail (Edminster 1954). Heavy snows and extreme winter temperatures can severely deplete populations and are often accompanied by swift declines in mountain quail numbers (Miller 1950, Jewett et al. 1953, Edminster 1954, Gutiérrez 1975). For an average winter, Edminster (1954) estimated an over–winter loss of 20% in California, and Pope and Crawford (1998) reported a 40% over–winter loss of translocated mountain quail in Wallowa County, Oregon. In the fall and winter of 1994/95, mountain quail in west–central Idaho had an over–winter loss of 47%, but in the fall and winter of 1995/96, when the heaviest snowfall was later in the winter, the over–winter loss was 75%. In both years the periods of greatest loss were correlated with the greatest snowfall (December 1994 and January

1995). Perhaps we should expect survival of mountain quail in this region to fluctuate based on severity of winter weather, especially snow depth at low elevations. Management activities to enhance winter cover and food source at low elevations could improve survival rates during harsh conditions.

The most common avian predators of adult and juvenile mountain quail are the Cooper's hawk (Accipiter cooperii), sharp-shinned hawk (A. striatus), and northern goshawk (A. gentilis) (Edminster 1954, Miller and Stebbins 1964, Rue 1973, Gutiérrez 1977). It has been suggested that these accipitrine hawks learn to hunt quail near feeding stations or water sources and can have a significant impact on local populations (Miller and Stebbins 1964, Gutiérrez 1977, 1980, P.E. Heekin pers. comm.). Significant mammalian predators include the domestic cat, gray fox (Urocyon cineraoargenteus), and bobcat (Felis rufus) (McLean 1930, Jewett et al. 1953, Edminster 1954, Miller and Stebbins 1964, Rue 1973). In west-central Idaho most known causes of mortality were attributed to avian predators. However, as development occurs along the Little Salmon River and its tributaries, and human population increases, loss of wintering mountain quail to domestic cats may increase.

Mortality rates for mountain quail in west-central Idaho are high compared to the few estimates available in the literature. During winter, mountain quail inhabit dense shrub thickets along creek bottoms; these thickets hold snow off the ground and provide protection from harsh weather and predators (Idaho Department of Fish and Game Commission 1951). If shrub thickets in riparian corridors are not dense enough to provide adequate protection from weather and predators, this may help explain the low survival rates of mountain quail in our study area. Support for this hypothesis comes from our covey use site data, where shrub canopy cover at mountain quail covey use sites in this study was only 15%, much lower than the 46% shrub canopy cover at use sites reported by Brennan et al. (1987).

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Appendix A. Common and scientific names of trees and shrubs present at mountain quail covey locations and independent sites during the fall and winter months 1994/95 and 1995/96, Little Salmon River study area, Idaho.

Amalanchier alnifolia	Serviceberry
Berberis repens	Oregon grape
Cercocarpus ledifolius	Curleaf mountain mahogany
Chrysothamnus spp.	Rabbitbrush
Cornus stolinifera	Red-osier dogwood
Crategus douglasii	Black hawthorn
Holodiscus discolor	Ocean-spray
Holodiscus dumosus	Spirea
Philadelphus lewisii	Syringa
Physocarpus malvaceus	Ninebark
Prunus virginiana	Chokecherry
Rhus spp.	Sumac
Ribes spp.	Currant
Rosa spp.	Rose
Rubus spp.	Blackberry
Salix scouleriana	Scouler's willow
Sambucus cerulea	Blue elderberry
Symphoricarpus albus	Snowberry
Syringa spp.	Lilac
Abies grandis	Grand fir
Acer glabrum	Rocky mountain maple
Betula occidentalis	Water birch
Juniperus spp.	Juniper
Larix occidentalis	Western larch
Malus spp.	Apple
Picea spp.	Spruce
Pinus ponderosa	Ponderosa pine
Populus trichocarpa	Black cottonwood
Pseudotsuga menzesii	Douglas-fir

Table 1. Summary of diurnal and nocturnal locations of radio–marked mountain quail recorded in the fall and winter months of 1994/95 and 1995/96, Little Salmon River study area, Idaho.

1994/95	# diurnal locations	# nocturnal locations	1995/96	# diurnal locations	# nocturnal locations
			Sept 95	12	
Oct 94	13	0	Oct 95	4	0
Nov 94	36	3	Nov 95	14	0
Dec 94	36	9	Dec 95	27	1
Jan 95	38	13	Jan 96	38	3
Feb 95	29	1	Feb 96	12	2
Mar 95	54	3			
Total	206	29		107	6

Table 2. Frequency by month of diurnal cover types used by mountain quail during the fall and winter months of 1994/95 and 1995/96, Little Salmon River study area, Idaho.

		Percent of observations in each cover type									
	N	Riparian/ tree/shrub	Riparian/ shrub	Mountain/ shrub	Conifer/ shrub	Grass/ scattered shrub	Agriculture	Residential garden	Road	Grass	Rocky outcrop
1994/95											
Oct	13	8	15	0	46	31	0	0	0	0	0
Nov	36	17	8	6	36	14	3	14	3	0	0
Dec	36	8	11	8	44	17	0	6	6	0	0
Jan	38	16	8	8	26	13	0	18	0	11	0
Feb	29	21	3	0	41	17	0	17	0	0	0
Mar	54	20	6	2	28	30	0	15	0	0	0
1995/96											
Oct	4	0	0	0	25	75	0	0	0	0	0
Nov	14	0	14	0	50	14	0	7	14	0	0
Dec	27	0	7	0	33	41	0	7	4	7	0
Jan	38	8	8	0	32	45	0	3	3	3	0
Feb	12	17	8	0	25	50	0	0	0	0	0

Table 3. Percent of mountain quail observations in different cover types under different snow depth conditions during the fall and winter months of 1994/95 and 1995/96, Little Salmon River study area, Idaho.

	Percent of observations in different mean snow depths (cm)							
	1994/95				1995/96			
	<1	1.1-5.0	5.1-9.9	>10	<1	1.1-5.0	5.1-9.9	>10
Cover type n	120	13	13	6	71	16	3	5
Riparian/tree/shrub	16	23	0	0	3	19	0	0
Riparian/shrub	9	8	8	0	7	13	33	0
Mountain/shrub	6	0	8	0	0	0	0	0
Conifer/shrub	36	23	54	67	39	19	0	20
Grass/scattered shrub	18	31	0	0	37	44	67	80
Agriculture	0	8	0	0	0	0	0	0
Residential garden	12	8	15	33	6	0	0	0
Road	1	0	15	0	4	6	0	0
Grass	3	0	0	0	4	0	0	0
Rocky outcrop	0	0	0	0	0	0	0	0

Table 4. Percent observations of different mountain quail behaviors during different time periods during the fall and winter months of 1994/95 and 1995/96, Little Salmon River study area, Idaho.

Time period	1994/95 (n = 152)			1995/96 (n = 95)		
	Active	Inactive	Unspecified	Active	Inactive	Unspecified
0530-1000	22	7	3	7	12	1
1000-1500	21	20	6	20	31	4
1500-1700	5	12	3	15	6	0
1700-2400	3	0	3	3	1	0

Table 5. Mountain quail home range size (ha) and distance moved (m) between consecutive locations during the fall and winter of 1994/95 and 1995/96, Little Salmon River study area, Idaho. Home range sizes were calculated using the Minimum Convex Polygon (MCP) and Adaptive Kernel (AK) methods.

	Mean ± SE	
	1994/95	1995/96
AK 80%	52.2 ± 7.1	83.2 ± 16.2
AK 70%	32.2 ± 5.3	59.7 ± 15.1
MCP 80%	25.3 ± 4.1	25.4 ± 8.0
MCP 70%	11.5 ± 2.3	14.9 ± 6.5
Mean distance (m)	405 ± 42	619 ± 156

Table 6. The period, number of locations, and number of days over which radio–collared mountain quail were monitored during the fall and winter months of 1994/95 and 1995/96, Little Salmon River study area, Idaho.

1994/95				1995/96			
Bird	Monitoring period	# days monitored	# locations	Bird	Monitoring period	# days monitored	# locations
0.008	10/94-3/95	163	19	0.027	9/13-21/95	9	2
0.027	11/94-12/94	26	3	0.090	11/8/95	1	1
0.059	2/95-3/95	40	7	0.181	11/95-2/96	107	16
0.090	11/94-3/95	150	24	0.182	2/26/96	1	1
0.108	11/6/94	1	2	0.209	10/95-1/96	95	11
0.129	11/94-2/95	118	17	0.286	10/95-11/95	1	2
0.160	11/94-3/95	145	20	0.299	11/95-2/96	118	17
0.181	3/22-27/95	10	3	0.330	11/95-2/96	81	10
0.182	3/4-13/95	10	2	0.388	12/95-1/96	62	10
0.209	10/94-1/95	85	10	0.438	9/95-1/96	133	10
0.241	3/27-31/95	5	2	0.498	12/95-1/96	60	8
0.242	3/4-22/95	19	3	0.518	12/95-1/96	16	2
0.258	2/95-3/95	52	8	0.539	12/95-2/96	63	10
0.279	2/95-3/95	31	7	0.600	1/10/96	1	1
0.286	10/94-2/95	116	13	0.649	10/95-2/96	121	14
0.299	10/94-2/95	116	15	0.667	10/95-2/96	121	14
0.330	11/94-2/95	96	7	0.690	1/4-22/96	19	4
0.360	10/94-3/95	159	24	0.727	12/95-2/96	63	10
0.388	10/94-1/95	94	10	0.749	9/21/95	1	1
0.419	10/94-2/95	115	11	0.788	12/95-1/96	54	8
0.438	10/94-1/95	83	14	0.798	1/9/96	1	1
0.460	11/94-3/95	150	24	0.818	11/14/95	1	1
0.479	11/94-2/95	94	13	0.820	12/95-2/96	63	10
0.498	10/94-1/95	88	9	0.859	9/6/95	1	1
0.518	10/94-12/94	65	8	0.918	11/95-1/96	64	8
0.539	10/94-12/94	51	5	0.978	12/95-1/96	33	5
0.539	2/95-3/95	29	5	1.009	11/95-2/96	72	13
0.557	10/94-12/94	58	7	1.030	12/1/95	1	1
0.579	10/94-12/94	61	8	1.118	9/6/95	1	1
0.600	10/94-12/94	44	7	1.159	9/6-28/95	23	3
0.600	2/95-3/95	33	6	1.213	9/6-27/95	22	3
0.619	11/94-12/94	49	9	1.300	9/5/95	1	1
0.619	3/2-31/95	30	6	1.359	10/95-1/96	77	8
0.649	11/94-2/95	94	13	1.608	11/95-1/96	55	6
0.667	10/94-2/95	107	14	1.698	12/1/95	1	1
0.678	2/95-3/95	35	7	1.737	11/95-1/96	86	9
0.699	12/7/94	1	1	1.797	11/95-1/96	70	7

1994/95				1995/96			
Bird	Monitoring period	# days monitored	# locations	Bird	Monitoring period	# days monitored	# locations
0.690	10/94-2/95	140	17	1.819	11/14/95	1	1
0.709	10/94-1/95	85	10	1.819	12/95-1/96	18	2
0.727	10/94-12/94	62	11	1.878	9/5/95	1	1
0.749	11/94-3/95	148	23				
0.770	10/94-2/95	116	13				
0.788	2/18/95	1	1				
0.818	10/94-2/95	107	14				
0.820	2/95-3/95	55	10				
0.839	2/95-3/95	31	7				
0.858	2/27/95	1	1				
.0859	2/95-3/95	31	6				
0.870	2/95-3/95	35	8				
0.918	10/94-12/94	67	8				
0.937	10/94-1/95	92	5				
0.959	10/94-3/95	158	19				
0.978	10/94-12/94	74	9				
0.978	3/13-31/95	19	4				
1.009	10/94-12/94	66	8				
1.009	2/95-3/95	33	6				
1.030	10/94-2/95	120	2				
1.059	2/95-3/95	39	7				
1.118	2/95-3/95	31	7				
1.159	2/95-3/95	31	7				
1.213	2/95-3/95	35	7				
1.300	3/13-22/95	10	4				
1.359	2/95-3/95	38	7				
1.379	2/95-3/95	40	7				
1.397	2/95-3/95	41	10				
1.420	10/94-1/95	110	13				
1.698	2/95-3/95	38	7				
1.797	2/95-3/95	18	8				
1.819	10/94-2/95	115	13				
1.838	11/94-3/95	148	21				
1.858	2/95-3/95	18	8				
1.878	2/95-3/95	39	6				
1.968	11/94-1/95	64	10				

Table 7. Number of mountain quail covey sites and independent sites surveyed by month during the fall and winter months of 1994/95 and 1995/96, Little Salmon River study area, Idaho.

	1994/95		1995/96	
Month	covey	independent	covey	independent
Nov	8	5	1	0
Dec	4	4	4	4
Jan	5	8	10	7
Feb	3	1	2	6
Mar	2	3	0	0

Table 8. Summary of MANOVA to test for differences in habitat characteristics at mountain quail covey sites and independent sites, fall/winter months of 1994/95 and 1995/96, Little Salmon River study area, Idaho.

Variable	Covey site		Independent site		*F*	*P*
	mean	SE	mean	SE		
% slope	48	6	45	4	0	0.9526
Elevation (m)	884	25	1186	46	34.38	0.0001
% canopy closure	47	4	39	5	0.9	0.3451
Shrub height (cm)	288	31	131	35	16.4	0.0001
Visual obstruction	4	0.6	1	0.2	18.58	0.0001
Snow depth (cm)	2	0.7	6	1	6.69	0.0117
% canopy cover	15	2	8	1	15.55	0.0002
Tree height (m)	3	0.7	8	2	7.59	0.0074
Tree dbh (cm)	26	6	41	8	2.17	0.1449
Nearest water (m)	142	27	372	50	16.49	0.0001

Table 9. Habitat characteristics at mountain quail covey sites by month during the fall and winter of 1994/95 and 1995/96, Little Salmon River study area, Idaho.

	Month											
	Nov		Dec		Jan		Feb		Mar			
Variable	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	*F*	*P*
Covey size	8.0	2.1	9.4	2.6	5.0	0.7	6.8	1.4	4.5	0.5	1.17	0.3416
% slope	37	9	37	10	63	10	33	9	79	13	1.36	0.2700
Elevation (m)	887	56	878	55	916	41	798	61	869	137	0.56	0.6968
% canopy closure	50	7	52	5	47	8	34	13	42	15	0.44	0.7786
Tree height (m)	2	1	3	2	2	1	5	3	0	0	0.72	0.5824
Shrub height (cm)	237	73	319	44	282	57	294	94	418	11	1.03	0.4064
Vertical cover	3.9	0.9	1.6	0.6	3.8	0.8	4.8	2.7	6.5	4.5	0.29	0.8796
Snow depth (cm)	5	2	0	0	2	1	1	1	0	0	1.49	0.2267
% canopy cover	15	4	14	3	14	3	17	6	21	1	0.87	0.4929
Nearest water (m)	248	71	103	56	143	40	49	20	50	30	1.18	0.3382

Table 10. The mean % canopy cover by species in each cover category (shrubs, trees, and woody debris) at covey versus independent sites in the fall and winter months of 1994/95 and 1995/96, Little Salmon River study area, Idaho.

% canopy cover 1994/95			% canopy cover 1995/96		
Species	covey	independent	Species	covey	independent
			Shrubs		
Serviceberry	31	10	Serviceberry	14	10
Oregon grape	0	19	Oregon grape	1	0
Rabbitbrush	0	1	Mountain mahogany	44	7
Red-osier dogwood	22	28	Rabbitbrush	0	2
Black hawthorn	47	24	Black hawthorn	35	17
Ocean-spray	20	30	Ocean-spray	8	26
Lilac	11	0	Syringa	17	3
Syringa	20	23	Ninebark	14	18
Ninebark	35	21	Chokecherry	8	0
Chokecherry	6	19	Sumac	1	0
Sumac	0	1	Current	14	0
Currant	31	4	Rose	7	0
Rose	16	7	Blue elderberry	1	0
Blackberry	8	5	Willow	1	11
Blue elderberry	6	3	Spirea	0	1
Willow	0	10	Snowberry	9	7
Spirea	0	2			
Snowberry	12	11			
Unknown	14	2			
			Trees		
Rocky mountain maple	11	12	Rocky mountain maple	16	15
Grand fir	0	48	Water birch	32	0
Water birch	59	23	Juniper	23	0
Exotic	51	0			
Juniper	37	0			
Western larch	0	22			
Apple	18	0			
Spruce	19	20			
Ponderosa pine	18	36			
Black cottonwood	32	0			
Douglas fir	0	19			
			Woody debris		
D&D	27	13	D&D	14	6
D&S	14	4	D&S	14	7
rock	23	0	CWD	9	5

Table 11. Percent of mountain quail mortalities attributed to known predators during the fall and winter months of 1994/95 and 1995/96 in west–central Idaho, Little Salmon River study area, Idaho.

	% deaths	
Source of mortality	1994/95	1995/96
Mammalian	43	14
Avian	38	41
Unknown	19	45

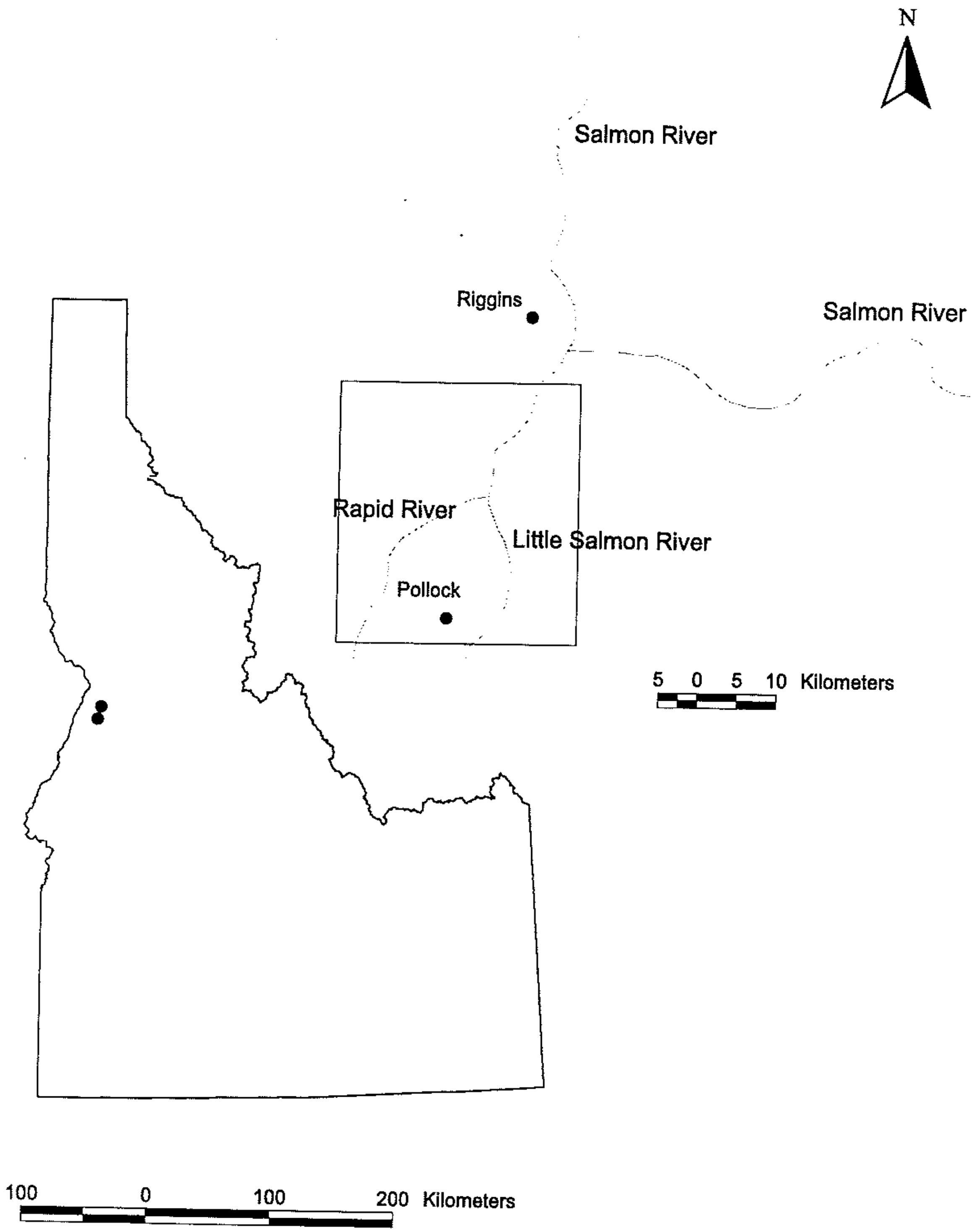

Figure 1. Mountain quail study area in west-central Idaho.

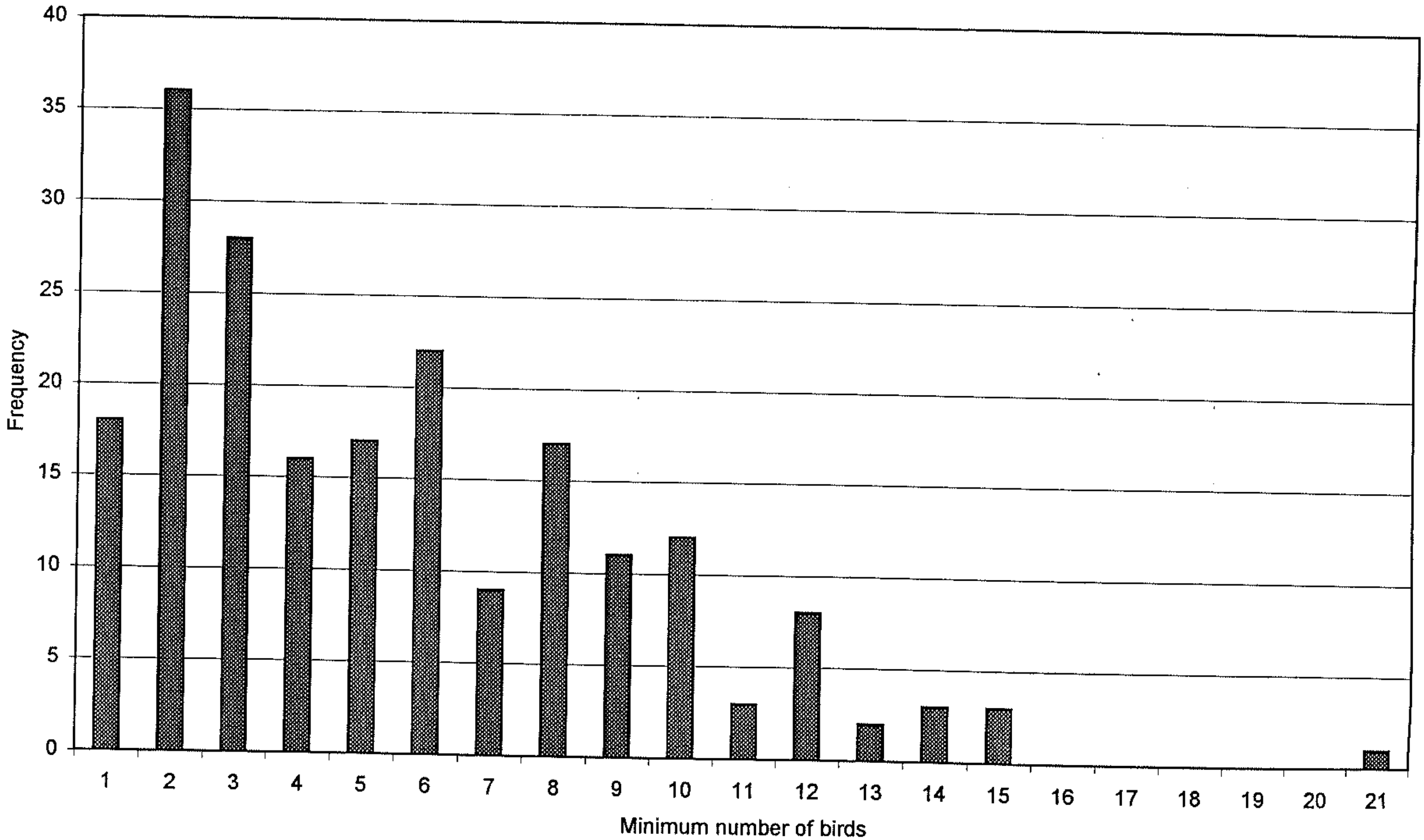

Figure 2. Frequency of mountain quail covey size observed in the fall and winter months of 1994/95, Little Salmon River study area, Idaho.

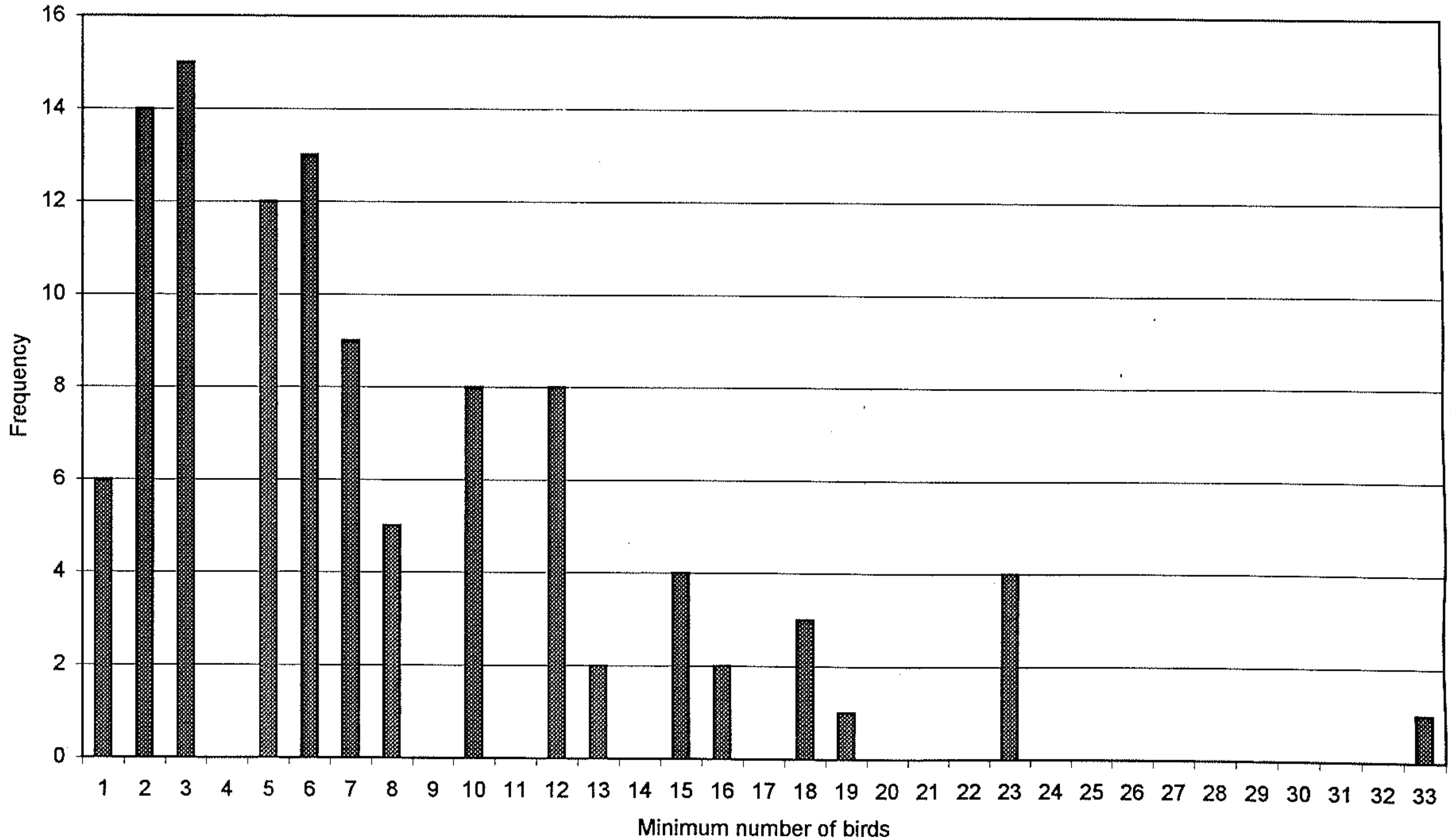

Figure 3. Frequency of mountain quail covey size observed in the fall and winter months of 1995/96, Little Salmon Riverstudy area, Idaho.

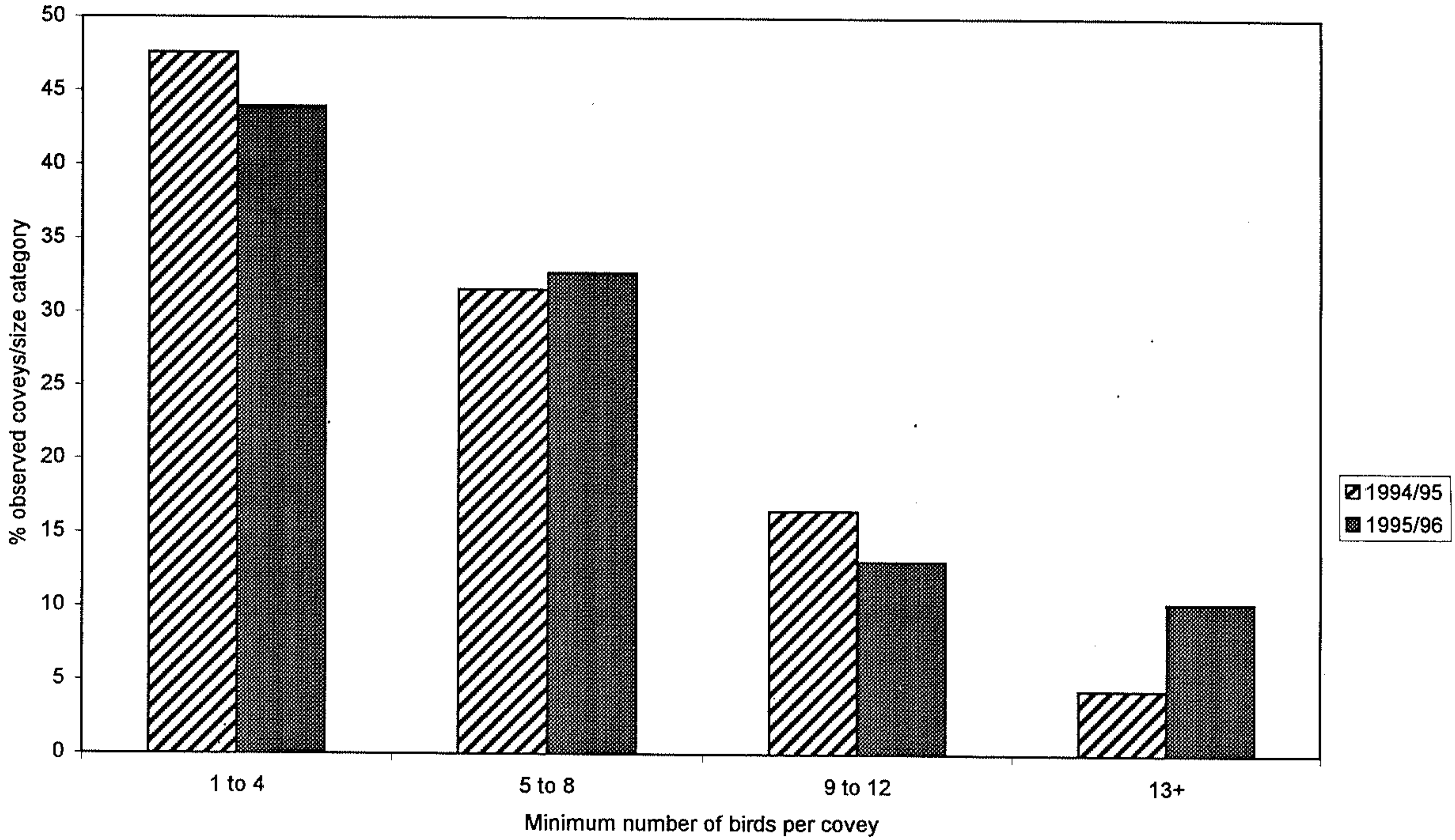

Figure 4. Percent of coveys observed in different size categories during the fall and winter months of 1994/95 and 1995/96, Little Salmon study area, Idaho.

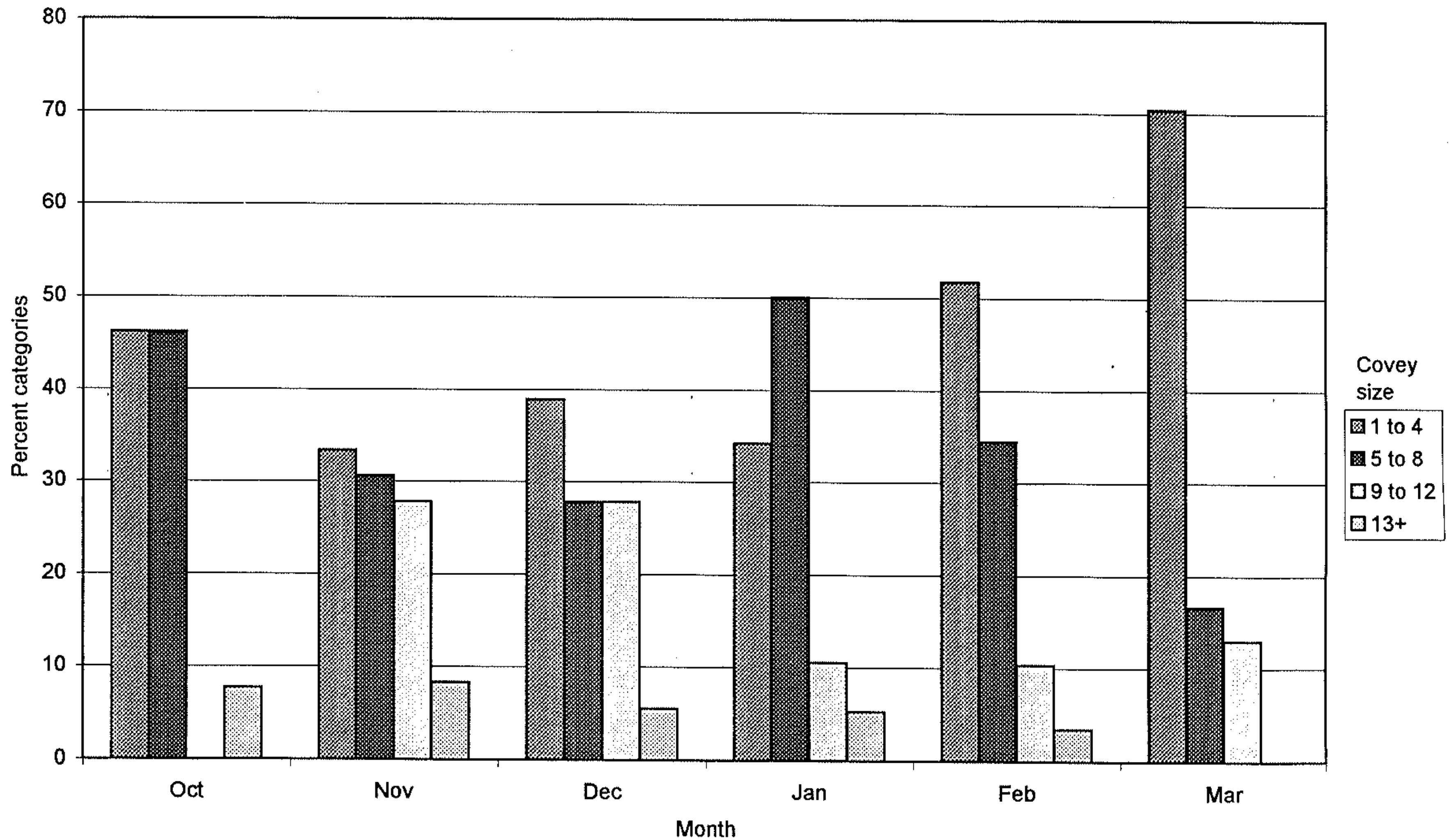

Figure 5. Percent of mountain quail covey size categories by month in the fall and winter of 1994/95, Little Salmon River study area, Idaho.

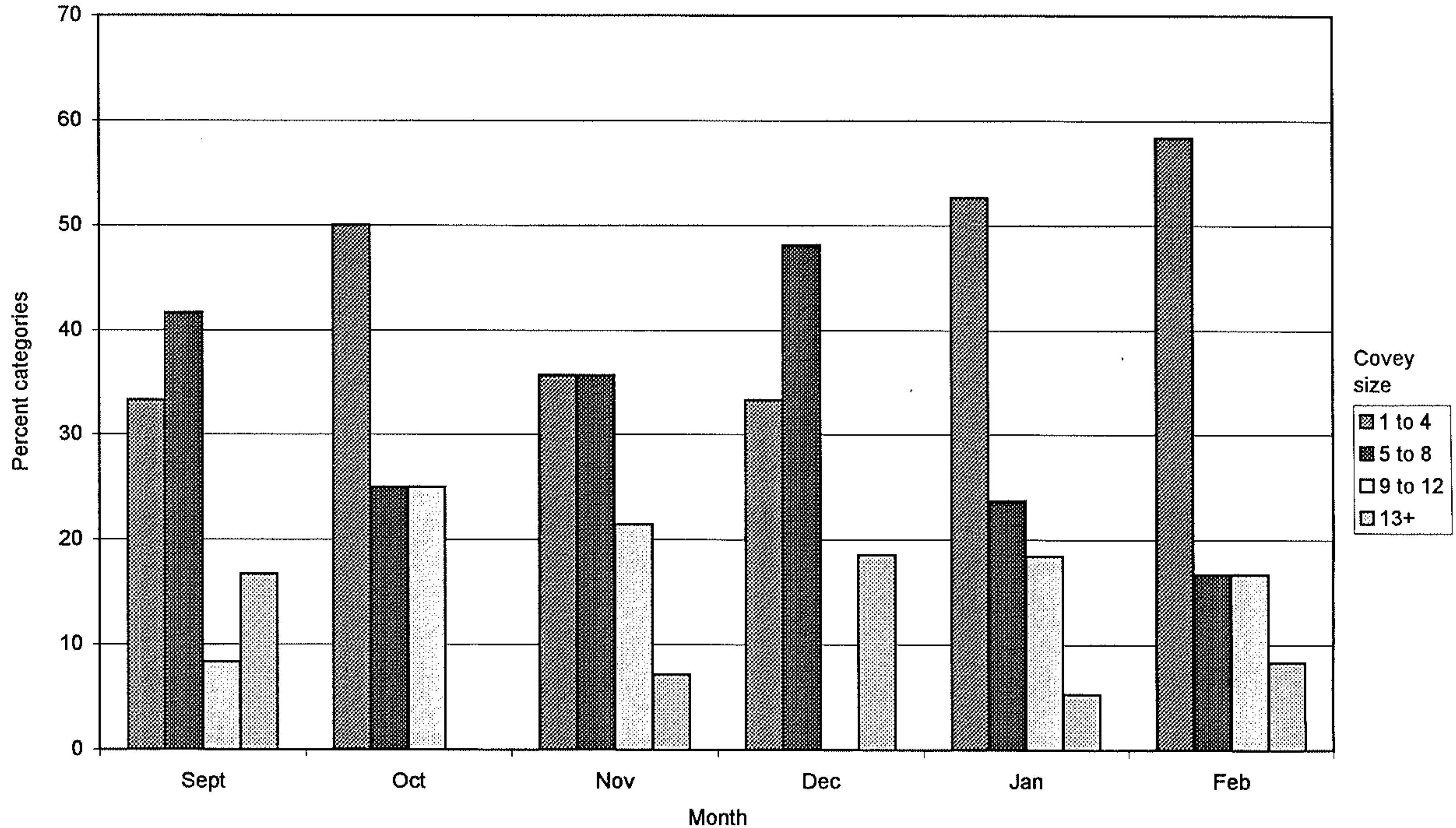

Figure 6. Percent of mountain quail covey size categories by month in the fall and winter months of 1995/96, Little Salmon River study area, Idaho.

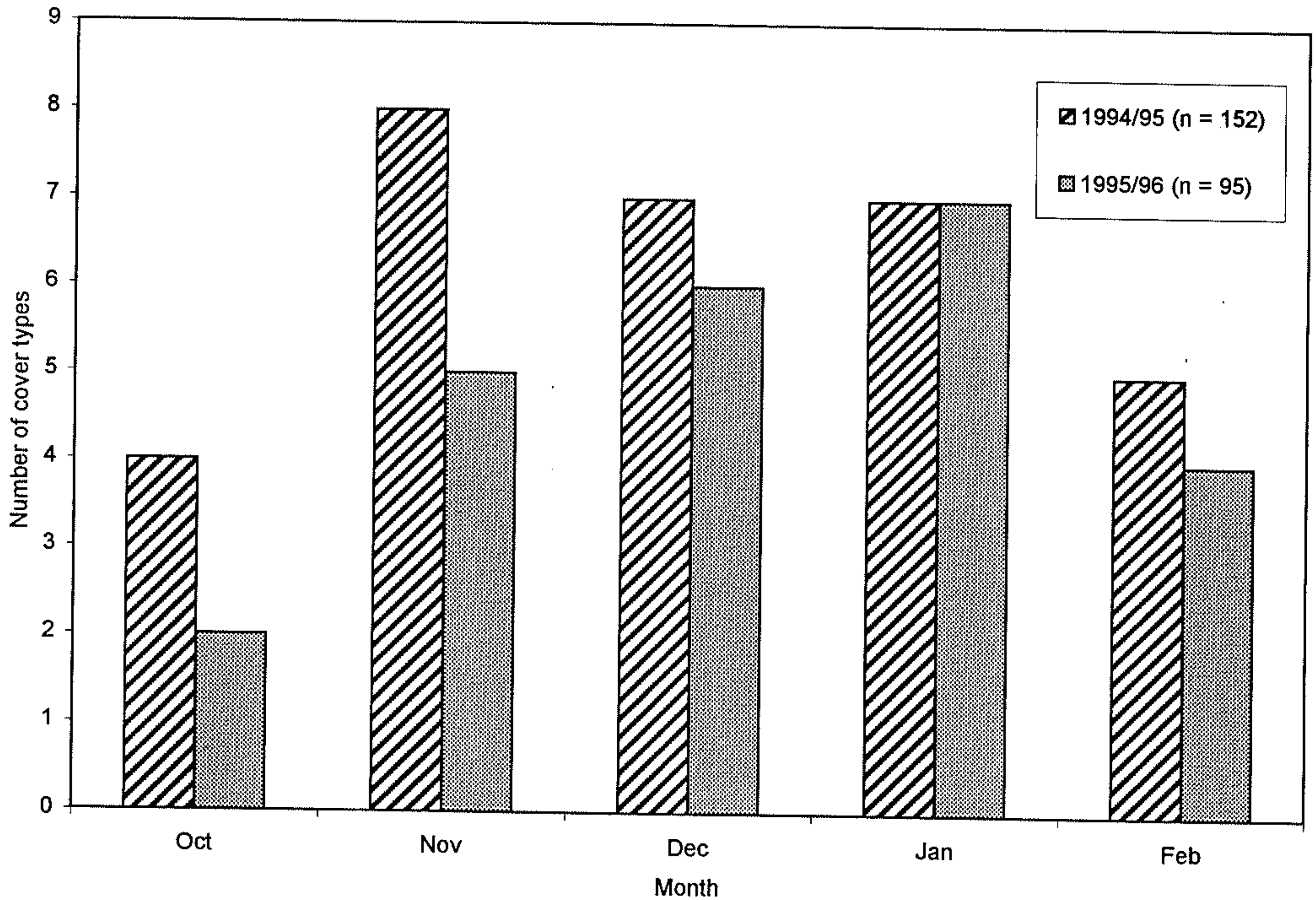

Figure 7. Number of different cover types used by mountain quail in diurnal locations during the fall and winter months of 1994/95 and 1995/96, Little Salmon River study area, Idaho.

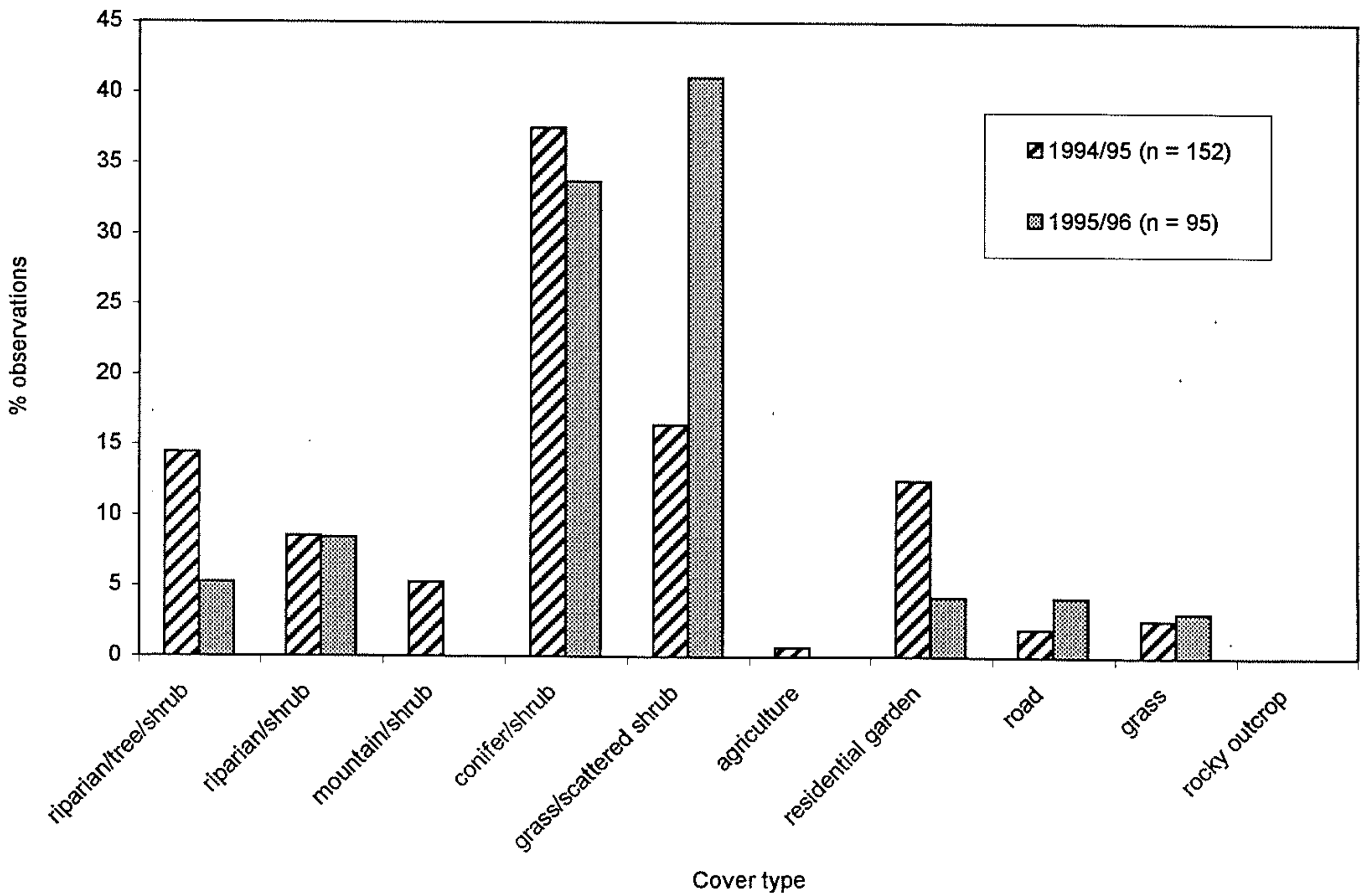

Figure 8. Frequency of use of different cover types from diurnal locations of mountain quail during the fall and winter months of 1994/95 and 1995/96, Little Salmon River study area, Idaho.

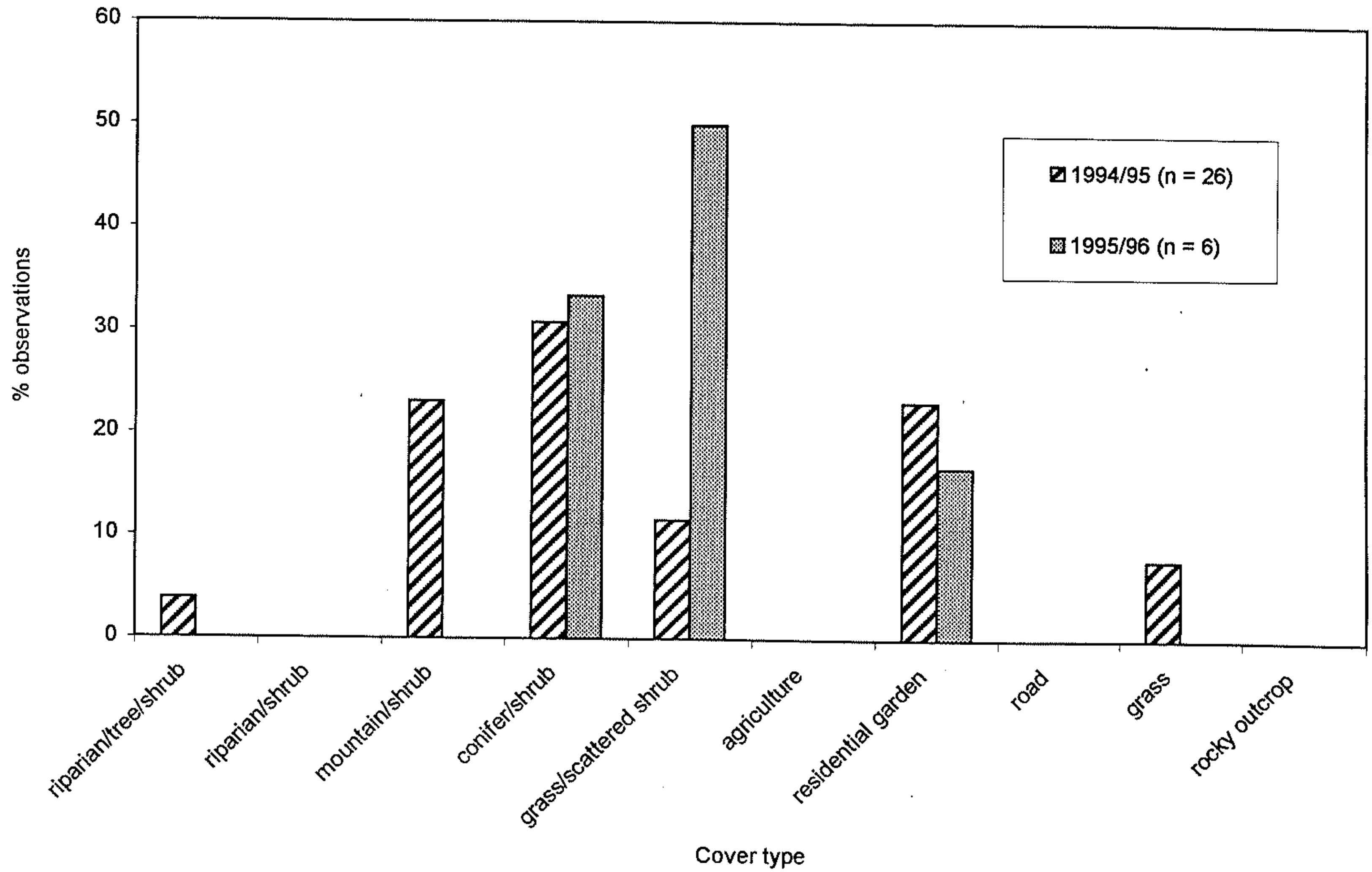

Figure 9. Percent of nocturnal observations in different cover types used by mountain quail during the fall and winter months of 1994/95 and 1995/96, Little Salmon River study area, Idaho.

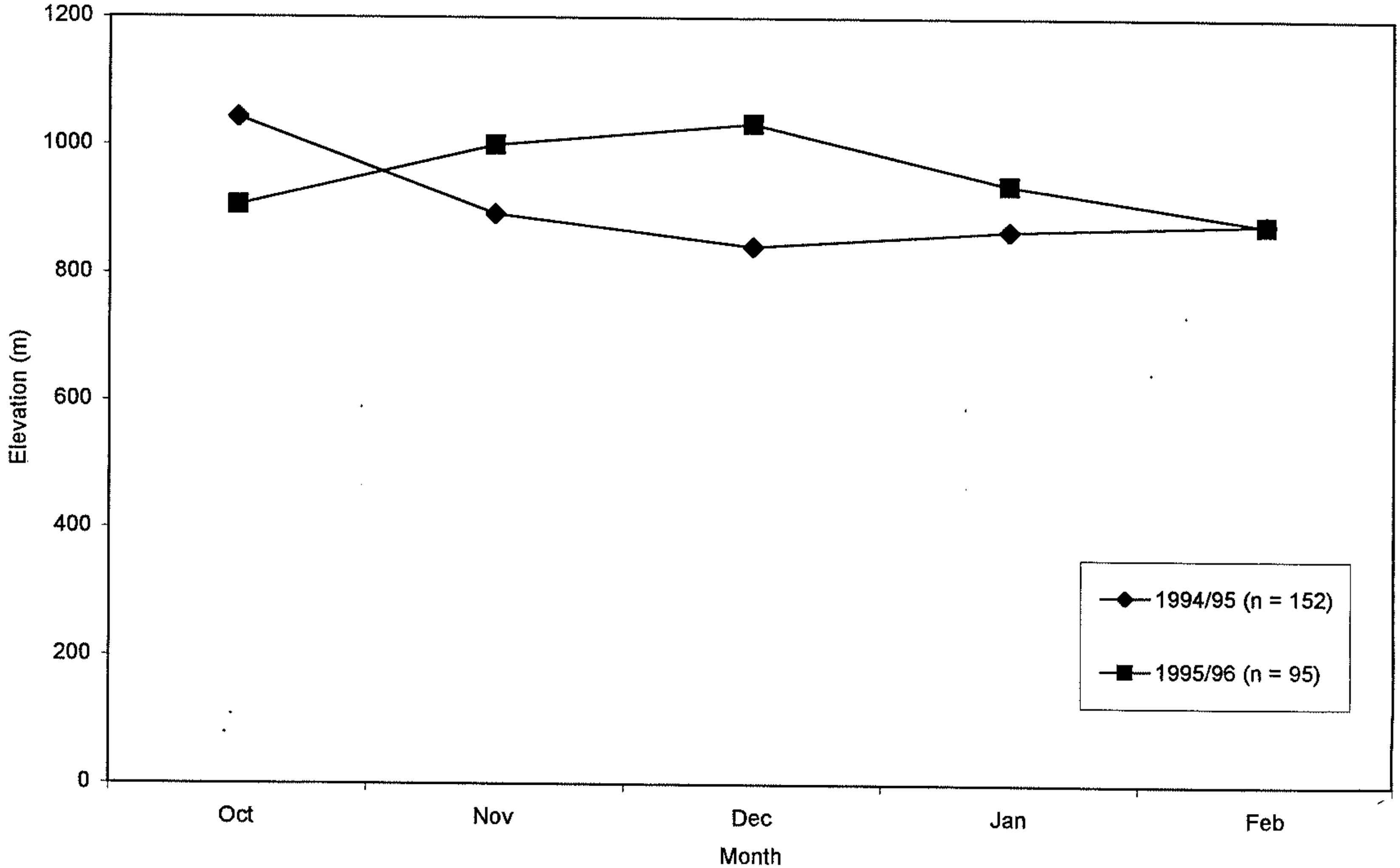

Figure 10. Mean monthly elevations (m) of diurnal mountain quail locations during the fall and winter months of 1994/95 and 1995/96, Little Salmon River study area, Idaho.

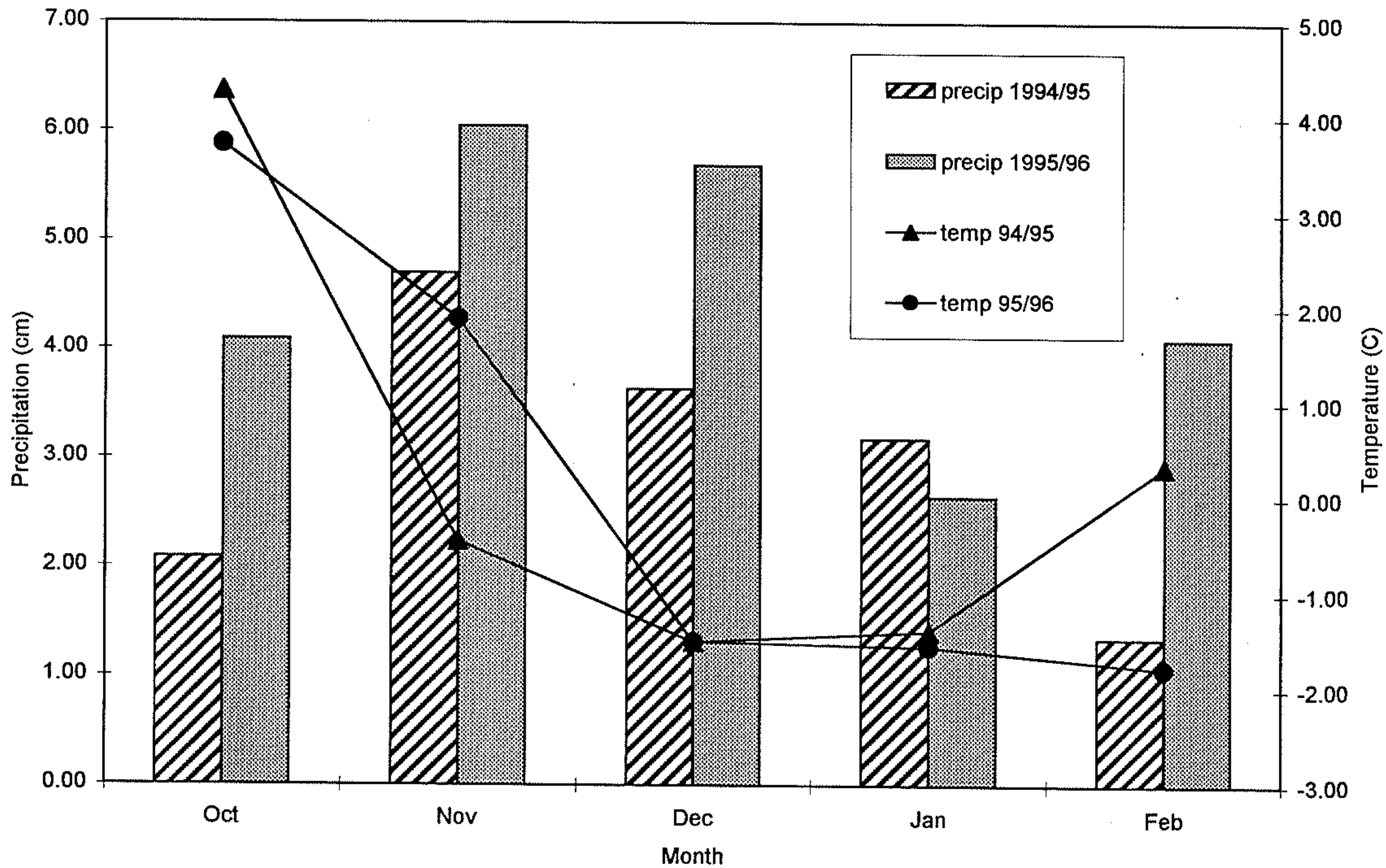

Figure 11. Mean monthly minimum temperatures and monthly total precipitation at Riggins, Idaho, during the fall and winter months of 1994/95 and 1995/96, Little Salmon River study area, Idaho.

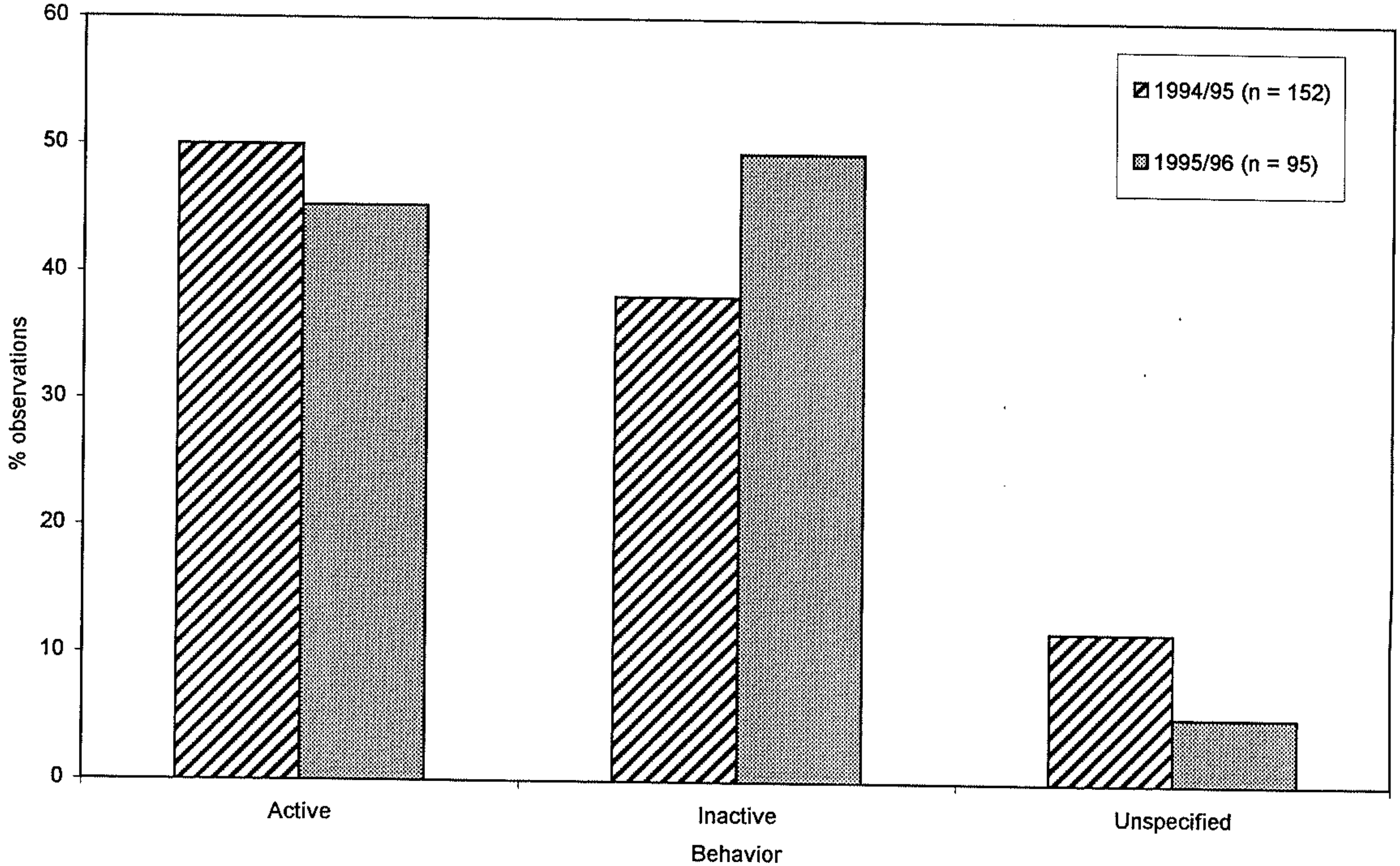

Figure 13. Percent of active, inactive, and unspecified observations of mountain quail during the fall and winter months of 1994/95 and 1995/96, Little Salmon River study area, Idaho.

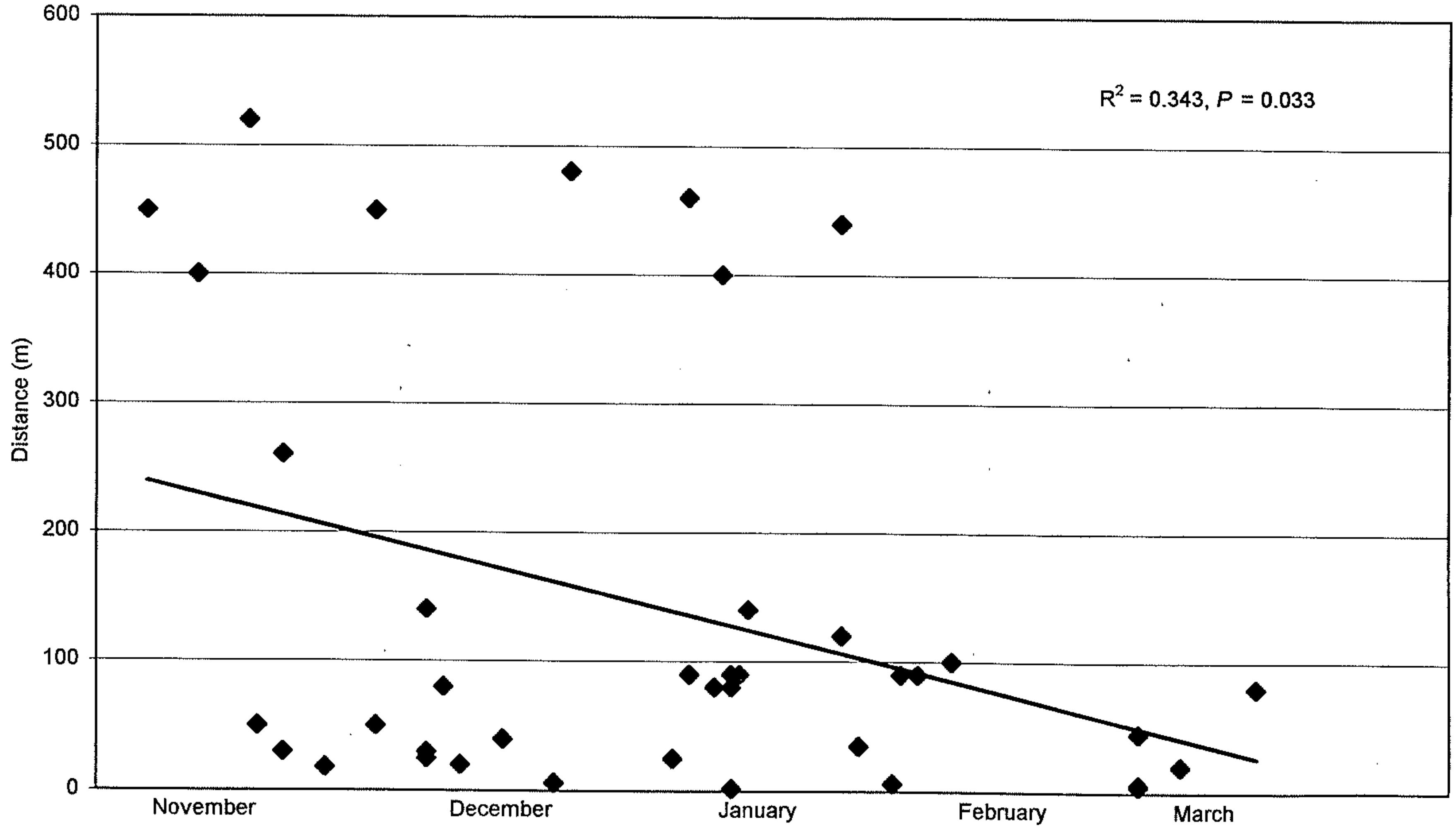

Figure 14. Distance (m) from mountain quail covey sites to nearest water source, fall and winter months of 1994/95 and 1995/96, Little Salmon River study area, Idaho.

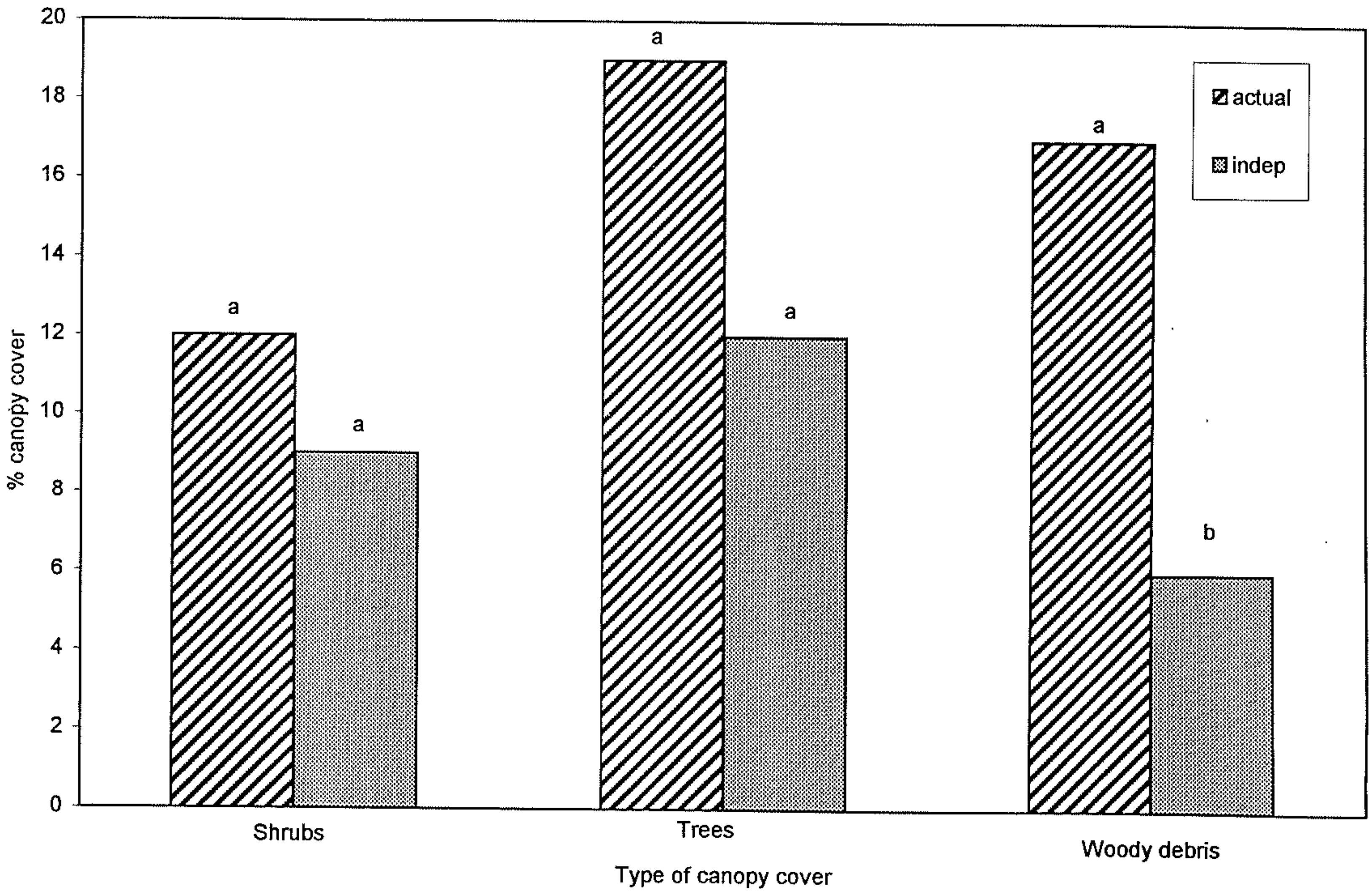

Figure 15. Composition of canopy cover at mountain quail covey sites and independent sites, fall and winter months 1994/95 and 1995/96, Little Salmon River study area, Idaho.

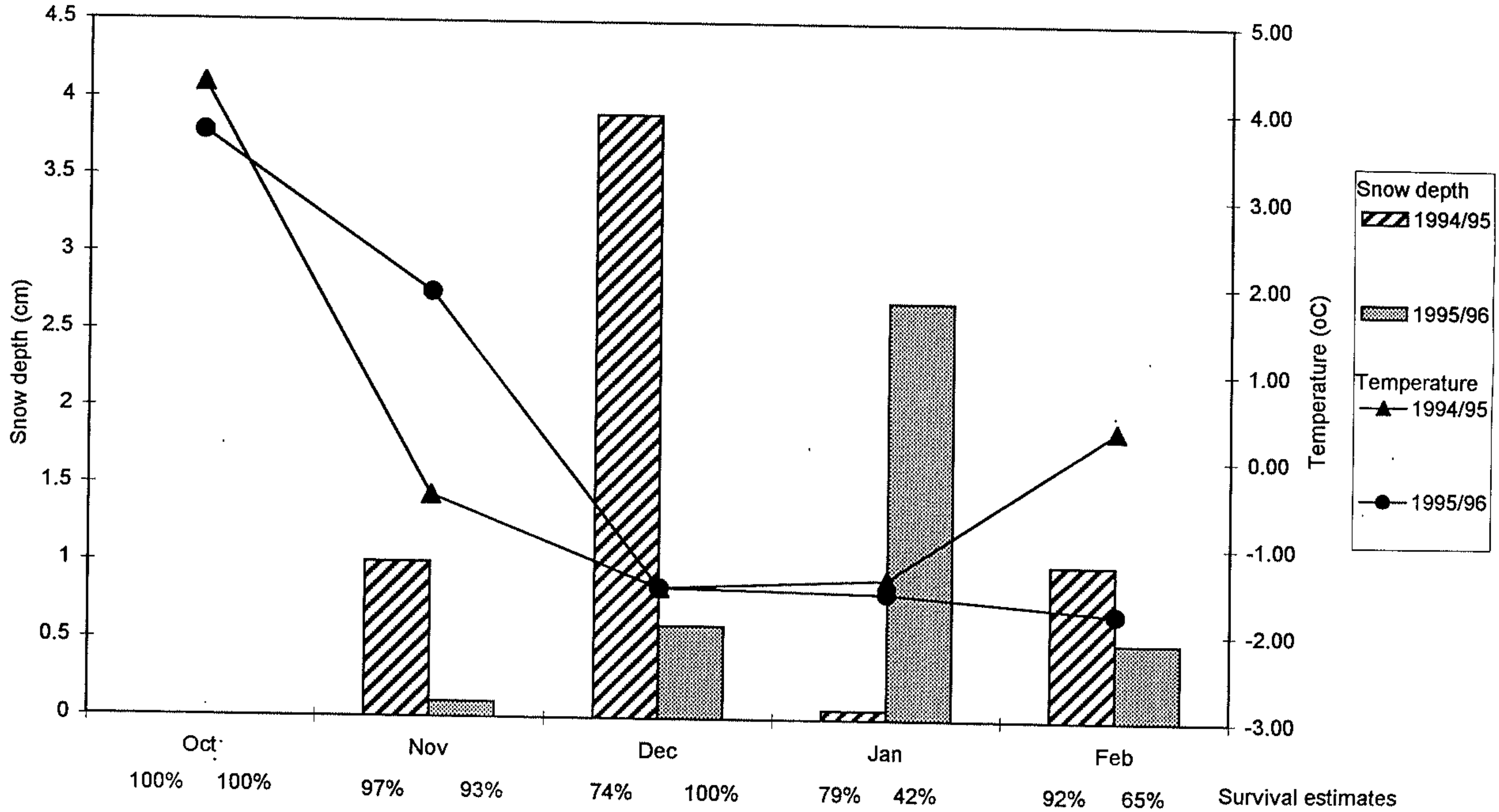

Figure 16. Mean snow depth at mountain quail locations, mean temperature at Riggins, Idaho, and monthly survival estimates during the fall and winter of 1994/95 and 1995/96, Little Salmon River study area, Idaho.